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THE CHEMICAL CONTROL OF PESTS *

MAN, like the rest of living creation, is engaged in a never-ending struggle for the necessities of life. There is competition from all directions. Many kinds of bacteria, for instance, while individually significant, can kill him by sheer weight of numbers. The crops upon which he depends for sustenance are open to attack by hosts of competing organisms; they may be destroyed by disease or smothered by the rank growth of weeds. Countless varieties of insects are inimical to human life and welfare. Some, like locusts and termites, devour foodstuffs or damage property; others, such as mosquitoes and lice, are dangerous as disease-carriers. Rats and mice and other vermin take serious toll in similar ways, and the age-old problem of the control of pests is still but partially solved.

The advance of chemistry has given new power to one of the oldest weapons in man's armament of self-protection, namely the use of poisons. The elaboration and application of poisonous substances dates from the earliest times. Those known to the ancients were primarily of natural origin, and included compounds of lead and arsenic, snake venoms, and extracts of certain plants, such as hemlock. We know, too, from the Homeric writings, that the Greeks used sulphur dioxide as a fumigant.

This list comprises many powerful poisons, but their practical use was, and is, limited inasmuch as their action is indiscriminate. They are as deadly to man as to his intended victims—sometimes more so—and their application is therefore attended by considerable difficulty and danger. A great stride forward was taken in the nineteenth century, with the discovery of poisons that are specific in their action. Ehrlich, the pioneer in this work, was able to show that certain arsenical compounds will destroy bacteria in the human body without at the same time doing irreparable damage to the tissues of the patient. There have been few more momentous discoveries, though, as has often happened in similar cases, subsequent progress was not at first rapid. Thousands of further poisons, including dyes, were investigated, but for many years the only other outstanding achievement to note was the discovery of a compound possessing specific action against the trypanosomes of malaria. Within the last decade, however, the chemical control of bacterial pests has been astonishingly strengthened, first by the

* Reproduced from *Endeavour*, 4, 16, 121-22, 1945.

discovery of the sulphonamide drugs—efficient specifics against staphylococci and streptococci—and more recently by the discovery of penicillin, a substance so highly specific against certain bacteria that the risk of giving a patient an overdose is negligible.

These discoveries were important not only because of their immediate application, but because they proved beyond the possibility of doubt that the search for specific poisons offered every prospect of reward. They thus opened up a new field of chemical activity—a field that is already bearing fruitful crops. We published in a recent issue of this Journal an article* based on a lecture by Dr. R. E. Slade, in which some recent work on the subject is described. A feature of much interest is that specific poisons have now been found for certain plants, and have already been applied in agriculture for the destruction of weeds. The original observation was that a number of growth-promoting compounds, chemically allied to α-naphthyl-acetic acid, have a powerful effect in the contrary sense when applied at greater concentrations. One of these substances, 'methoxone', has now been developed commercially, and has proved of very considerable value in freeing cereal crops — which are almost unaffected by it—from harmful weeds such as charlock.

The pyrethrums and derris are examples of natural poisons with a specific action against insects. To them have been added during the past few years the synthetic substances 'D.D.T.' (dichlorodiphenyl-trichloroethane) and 'gammexane', the γ-isomer of benzene hexachloride. These substances, although not very toxic to animals and almost without effect upon the leaves of plants, are among the most powerful insecticides known.

The majority of the specific poisons hitherto investigated were discovered either by chance or by the laborious examination of thousands of different compounds in the hope that, sooner or later, useful ones would be found among them. An urgent need for the speedy development of this important branch of applied chemistry is a more logical method of search ; and as this can come only from an understanding of the mechanism of specific toxicity it is satisfactory to know that a beginning has been made in this direction. There is indeed evidence that at least some specific poisons act in virtue of their chemical resemblance to substances which play essential parts in metabolism. One such substance is *p*-aminobenzoic acid, to which the sulphonamides have a general similarity of structure ; and Fildes and Woods have suggested that the toxic action of the sulphonamides may be explained on the assumption that their molecular architecture enables them, so to speak, to act as faulty keys that enter, but jam, locks properly turned by *p*-aminobenzoic acid. By replacing this acid in a cell re-action, they distort or stop the normal course of the metabolism. Similarly, it has been suggested that the toxic action of gammexane is attributable to its structural resemblance to the natural form of inositol. These hypotheses are still highly speculative, but they form a point of attack and may lead to a gradually increasing comprehension of the mode—or modes—of action of specific toxicity.

Whether progress be rapid or slow, the discovery of specific poisons makes it clear that we approach an age in which the destruction or control of pests by chemical means will become more and more practicable. At first sight, the prospect would appear wholly delectable: fields and gardens without weeds, granaries and warehouses without rodents, each bacterial disease with its appropriate chemical antidote. Caution, however, bids us pay attention to the fact that dangers may lie ahead. Man occupies a place in a complex system of interacting organisms, among which a state approximating to dynamic equilibrium exists. He now possesses the means of radically altering several of the factors in this system, and is naturally tempted to employ them at once to what he believes will be his advantage. Yet while the immediate effects of such control may be favourable, human foresight is still too limited for us to be certain that the ultimate effects will continue to be favourable. On the contrary, it is easily conceivable that destruction of one pest may promote the increase of another upon which it normally preys; for, as Augustus de Morgan wrote:

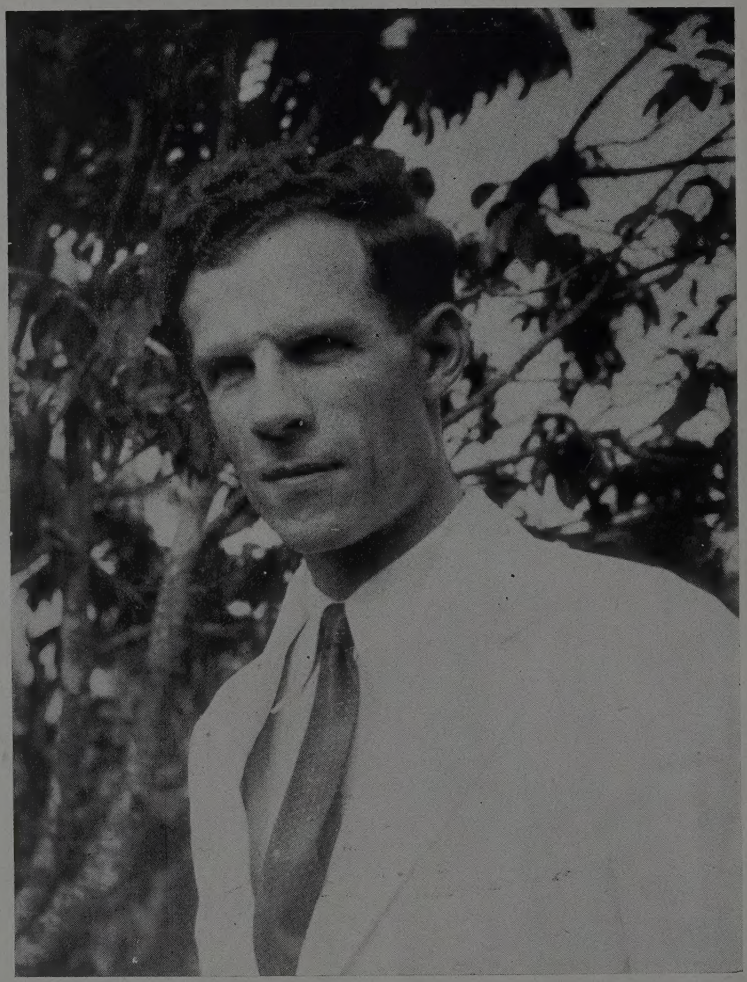
> "Great fleas have little fleas upon their backs to bite 'em,
> And little fleas have lesser fleas, and so *ad infinitum*."

Interference with the balance of nature must be attended by more or less risk, and it does not require a very vivid imagination to picture the consequences of, say, the destruction of the nitrifying bacteria of the soil. Such a complete disaster may be unlikely, but minor ones of the same kind could be sufficiently disturbing, and their possibility could not be ruled out if chemical control of pests were applied without due discretion and preliminary investigation.

These general conclusions are of course obvious upon reflection ; unfortunately there is little evidence that they are receiving serious study. It seems not improbable that future use of selective poisons may do more to change the face of living nature than any previous application of scientific knowledge ; it would be a tragedy if, through premature or ill-considered action, discoveries which have immense power for good should be so mishandled as to occasion misfortune and evil.

The subscription to *Tropical Agriculture* is six shillings per annum, post free, Trinidad currency, to all countries within the British Empire or seven shillings and sixpence, post free, Trinidad currency, to all other countries. Subscriptions can commence at any time during the year.

* *Trop. Agriculture*, 22, 6, 98-99, 1945.



The Late Professor A. M. ADAMSON, M.A., B.Sc., Ph.D.

OBITUARY

Professor A. M. Adamson

It is with profound sorrow that we have to record the death at the age of forty-four of Professor A. M. Adamson on 24th December, 1945, in San Francisco, California. Although many of his friends and colleagues knew that he had been seriously ill for several months, the news came as a very real shock to those who knew him. Adamson's exceptional personal charm endeared him to all with whom he came into contact and his quiet presence will be greatly missed. He was beloved by his friends for his outstanding characteristics of kindliness, simplicity, and utter sincerity. Among College children he was a great favourite for he was one of those rare beings whom a child would adopt instantly as a friend.

Alastair Martin Adamson was born at Ardrossan, Scotland, on 17th October, 1901, one of the sons of the Reverend Robert Adamson, D.D. He was educated at the Ardrossan Academy and at St. Andrews University, where he obtained his M.A. in 1922 and his B.Sc. degree in the following year. In 1923 he was awarded a Research Fellowship at St. Andrews, which he held until 1924, when he was appointed Assistant in Zoology to Professor Sir D'Arcy Wentworth Thompson, F.R.S. His first love was marine zoology, and it came as a great disappointment to him when he was unsuccessful in his application for appointment as zoologist on the expedition of the R.R.S "*Discovery*" for the exploration of the Antarctic. When a few years later, this position, which he prized so highly, was offered to him, he was already engaged in research in the Pacific and was unable to accept it.

In 1926 Adamson was awarded a Commonwealth Fund Fellowship, which made it possible for him to undertake research in the U.S.A. For the two years' tenure of his Fellowship he elected to work at the University of California. Here he devoted himself to marine zoology and made a detailed study of a group of minute organisms forming an important constitutent of the marine plankton and playing a significant rôle in the economy of the sea. Although most of his time was spent on the Pacific Coast, which he explored from Alaska to Mexico, he travelled widely throughout the United States. He came to admire much in that great country and made many friends there.

At the expiry of his Commonwealth Fund Fellowship in 1928, Adamson joined the staff of the Pacific Entomological Survey under the Directorship of a fellow Briton, Mr. Edward P. Mumford. This ambitious Survey was organized and financed by the Hawaiian Sugar Planters' Association and the Bernice P. Bishop Museum of Honolulu, and aspired to study the fauna of the Pacific. Adamson spent the better part of two years in the Marquesas Islands, an extremely isolated archipelago almost exactly in the centre of the Pacific, where with Mumford he made extensive collections of invertebrate animals. He also visited Tahiti in the Society Islands and later spent about two years in the Hawaiian Islands. Resulting from his work in the Pacific, he published several papers, one of which he presented for his Ph.D. degree of the University of California, which he gained in 1935.

In 1933 Adamson was appointed to the staff of the Imperial College. His first position was as Lecturer in charge of the Department of Entomology, but two years later he was appointed Reader. In 1938 he was made Professor of Entomology, which position he held until his death. In Trinidad he threw himself with characteristic enthusiasm into a study of the rich fauna of the island, and his early collecting expeditions were often made in company with the late Professor F. W. Urich, whose knowledge of the local fauna was unsurpassed. He built up a small zoological museum, which has proved to be invaluable in the teaching of zoology, and completely reorganized the rather antiquated entomological collection at the College. Due to his enterprise, the insect collection has been much extended and is now thoroughly up-to-date and housed in fireproof steel cabinets of the most modern construction.

The biological control of insect pests interested him greatly, and he will long be remembered by cacao planters and others for his work on the introduction from the Gold Coast of a parasite of the cacao thrips, which has now become established in Trinidad and elsewhere in the West Indies. He was also keenly interested in the geographical distribution of insect pests, and especially in the control of crop pests by restricting their spread through plant quarantine measures. For some ten years he was Secretary and Entomologist to the Plant Quarantine Committee of the British West Indies and in charge of the Plant Quarantine Station at St. Augustine.

The study of termites, however, was Adamson's major interest. This important group of insects absorbed him, and he not only amassed an immense collection of Trinidad termites, but also possessed an unrivalled knowledge of the habits of the sixty or more species occurring in the island. Many of his more recent publications were devoted to termites, and, at the time of his death, he was completing an account of the biology of the termites of Trinidad, which it is to be hoped will be published in due course.

A picture familiar to many is that of Adamson' tall figure, machete in hand and haversack slung at his side, striding along a forest trail in the mountains of the Northern Range, or, surrounded by a group of students, absorbed completely in cutting open a termite nest. Many students and others will long remember the expeditions—which

he so dearly loved—to the Toco coral reef, Arena Forest, Aripo Caves, Mount El Tucuche and many other parts of Trinidad.

Adamson was no narrow scientist. He read widely and had a deep love and appreciation of art and music. In 1933 he married Florence Jacobson of San Francisco, a graduate of the Universities of California and Columbia and a noted psychologist and sociologist. She not only entered into the social activities at the College but identified herself with much social and welfare work in Trinidad. Adamson's untimely death comes as a grievous blow to the College, and his passing will be mourned by his colleagues and many friends. To his widow and adopted son we extend our deepest sympathy in their loss.

A STATISTICAL COMPARISON OF THE INFLUENCE OF CRUDE FIBRE ON THE DIGESTIBILITY OF ROUGHAGE BY BOS INDICUS (ZEBU) AND BOS TAURUS CATTLE

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FROM time to time attempts have been made to compare tropical and temperate zone cattle from the standpoint of their relative capacities to digest and utilize feedingstuffs. Thus Matson (1928-29) in a Note to the Royal Commission on Agriculture in India, expressed the view that the Indian Zebu "extracts" 75 per cent. of the dry matter of its ration as compared with 60 per cent. in the case of European breeds. Warth (1927-28) felt that relatively high net energy values were obtained for certain tropical Indian hays because some breeds of Zebu were superior to others in digestive capacity. Warth and Gossip (1930) reported that their experimental calves could "thrive on rations with much wider nutritive ratios than those recommended in European standards". However, since these workers aimed at a lower rate of growth than is implied by the European standard this finding might be expected. Sayer (1943) found that when European standards of feeding were applied to the Pusa pedigree Sahiwal herd the milk production was lower than when less generous rations were offered. Owing to the various changes in management introduced at the same time, together with the lack of experimental control animals, the finding is open to doubt. French (1940), comparing Zebu with cross-bred (Ayrshire × Zebu) animals receiving the same rations, found no difference in digestive capacity.

The above statements introduce two comparisons, at least by implication: that of relative efficiency in digestive processes and that of relative efficiency in the utilization of absorbed nutrients. Too little is known about the fundamentals of metabolism in *Bos indicus* to make it worthwhile considering the latter comparison. Attention is therefore given to the former where, in the case of each species, a considerable body of information exists.

During recent years several contributions (discussed below) have appeared concerning the influence of crude fibre on the digestibility of rations by temperate zone stock. A statistical study was made, therefore, of this influence in *Bos taurus* animals consuming common temperate zone roughage in a normal habitat (North America) and in *Bos indicus* animals consuming common tropical zone roughage in a normal habitat (India).

Origin of data

The results used in the present study were obtained from the available literature. The data for Zebu cattle were collected from Indian sources. The data for *Bos taurus* were collected from American and Canadian sources. This restriction to North American work in the case of *Bos taurus* has the advantage of permitting an additional comparison to be made, namely, with the regression equation of Axelsson (1938) for European cattle.

Data for roughages, excluding silages, alone were chosen. The purpose of this restriction was to avoid complications arising from associated digestibility effects in mixed rations. Although any improvement in the digestibility of individual constituents which may arise when different feedingstuffs are combined in a ration has been shewn to be slight or non-existent for *Bos taurus* (Ewing and Smith (1918); Ewing, Wells and Smith (1925); Ewing and Wells (1915); Mertins (1933); Watson, Davidson, Woodward, Robinson and Muir (1939-40)) comparable studies for *Bos indicus* have not yet been undertaken. Of those experiments where roughage was fed alone only data from experiments where the plane of nutrition was at, or near, maintenance were included. Watson, Muir and Davidson (1934-5), surveying the available information, concluded that any effect of the plane of nutrition on the digestibility of roughage was either slight or non-existent. Again, in the case of *Bos indicus*, comparable studies have not been made.

There were collected 101 cases from the American literature and 166 cases from the Indian. In a few cases only the average value for a group of animals was given. This was treated as a single variate in each case.

Statistical method

The regression co-efficient (b_{xy}) of the digestibility of the organic matter of the feeds (x) on the percentage of crude fibre (y) in the dry matter was calculated. Attention was given to the digestibility of the organic matter rather than to the digestibility of the total dry matter to eliminate the confusing influence of variations in ash content of the fodders. The digestibility

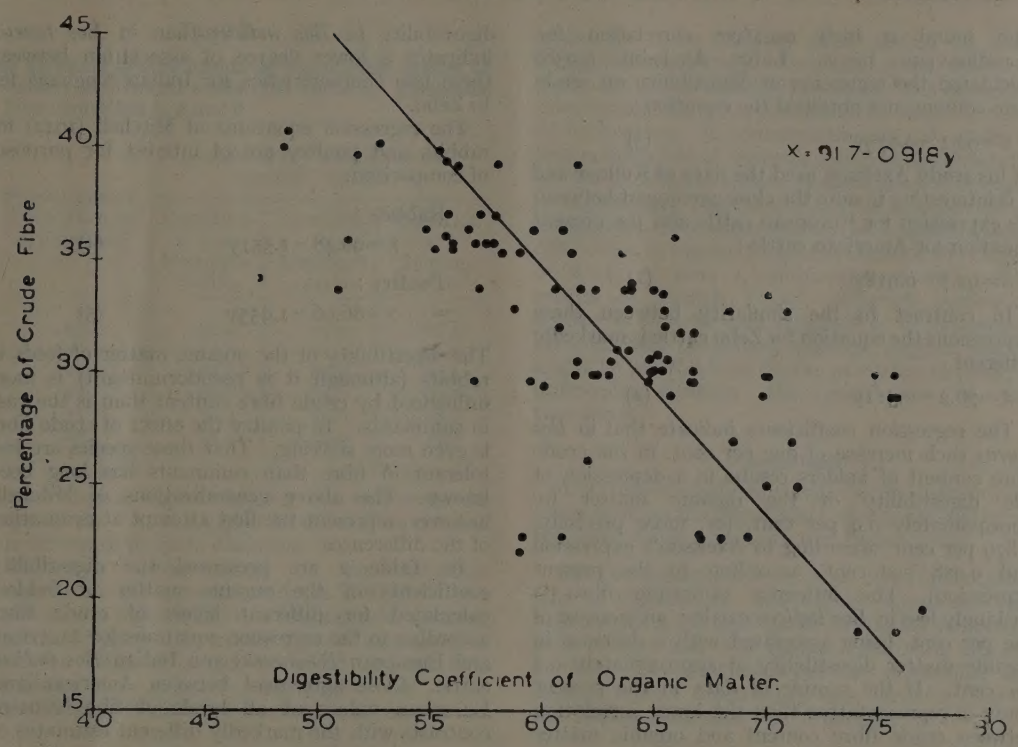

FIG. 1. Showing the influence of crude fibre content (y) on the digestibility coefficient of organic matter (x) for North American roughages fed to *Bos taurus*. The regression line and equation of x on y are also shown.

co-efficient of the ash is of very limited nutritional significance and of none in consideration of the ration as an energy source.

Results

The average crude fibre content for the American data was 32.1 per cent. of the dry matter. The corresponding value for the Indian fodders was 33.4 per cent. The average digestibility of the organic matter was 62.2 per cent. for the American data and 59.1 per cent. for the Indian.

The equations for the regression of digestibility of the organic matter on the crude fibre content of the dry matter were:

Bos taurus

$$x = 91.7 - 0.918y \qquad (1)$$

Bos indicus

$$x = 76.2 - 0.511y \qquad (2)$$

The difference between the regression coefficients (−0.918 and −0.511) is significant at 1 per cent. point.

The coefficients of correlation between the percentage of crude fibre in the dry matter and the digestibility of the organic matter were highly significant in both cases: the respective values of *r* were: *Bos taurus*, −0.680; *Bos indicus*, −0.417.

These results are summarized in Table 1. In Fig. 1 are presented the data for the American studies together with the regression line. In Fig. 2 are presented the data for the Indian studies together with the regression line. In Fig. 3 the regression lines for American *Bos taurus* cattle, for Indian Zebu cattle and for the European *Bos taurus* of Axelsson (1938) are presented.

Table 1

Statistics of digestibility trial data for *Bos taurus* and *Bos indicus* cattle

Statistics	*Bos taurus*	*Bos indicus*
Number of cases	101	166
Average %, crude fibre in dry matter	32.1	33.4
Average %, digestibility of organic matter	62.2	59.1
Regression coefficient: Digestibility on crude fibre ...	− 0.918	− 0.511
Correlation coefficient: Digestibility and crude fibre content	− 0.680	− 0.417

Discussion

The first attempt statistically to relate digestibility of feedingstuffs to their crude fibre content appears to have been that of Jarl (1938)

who found a high negative correlation for Scandinavian hays. Later Axelsson (1938) calculated the regression of digestibility on crude fibre content and obtained the equation :

$$x = 90.1 - 0.879y \qquad (3)$$

In his study Axelsson used the data of Kellner and it is interesting to note the close agreement between his expression for European cattle and the present equation for American cattle :

$$x = 91.7 - 0.918y \qquad (1)$$

In contrast to the similarity between these expressions the equation for Zebu cattle is markedly different :

$$x = 76.2 - 0.511y \qquad (2)$$

The regression coefficients indicate that in *Bos taurus* each increase of one per cent. in the crude fibre content of fodders results in a depression of the digestibility of the organic matter by approximately 0.9 per cent. (or, more precisely, 0.879 per cent. according to Axelsson's expression and 0.918 per cent. according to the present expression). The influence of crude fibre is strikingly less in *Bos indicus* cattle : an increase of one per cent. being associated with a decrease in organic matter digestibility of approximately 0.5 per cent. If the sample of data in the present study is representative then the lower correlation between crude fibre content and organic matter digestibility in *Bos indicus* than in *Bos taurus* indicates a lower degree of association between these two characteristics for Indian roughage fed to Zebu.

The regression equations of Mitchell (1942) for rabbits and poultry are of interest for purposes of comparison.

Rabbits :

$$x = 96.48 - 1.551y \qquad (4)$$

Poultry :

$$x = 86.06 - 1.955y \qquad (5)$$

The digestibility of the organic matter of feeds in rabbits (although it is pseudoruminant) is more influenced by crude fibre content than is the case in ruminants. In poultry the effect of crude fibre is even more striking. That these species are less tolerant of fibre than ruminants has long been known. The above generalizations of Mitchell, however, represent the first attempt at evaluation of the differences.

In Table 2 are presented the digestibility coefficients of the organic matter of fodders calculated for different levels of crude fibre according to the regression equations for American and European *Bos taurus* and Indian *Bos indicus* cattle. Close agreement between American and European values at all levels of fibre content contrasts with the markedly different estimates of

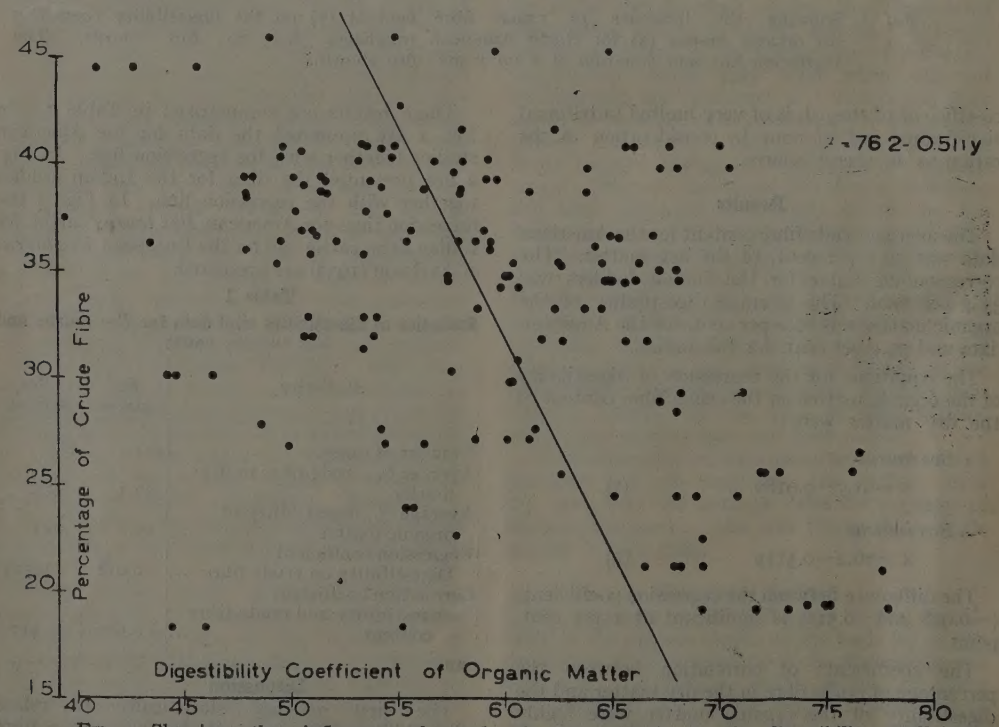

FIG. 2. Showing the influence of crude fibre content (y) on the digestibility coefficient of organic matter (x) for Indian roughages fed to *Bos indicus*. The regression line and equation of x on y are also shown.

Table 2

The digestibility coefficients of the organic matter of fodders of different crude fibre content. Calculated from equations 1, 2 and 3

Percentage of crude fibre in dry matter	Digestibility coefficient of organic matter		
	Equation 3 European cattle	Equation 1 American cattle	Equation 2 Indian cattle
15	76.9	77.9	68.5
20	72.5	73.3	66.0
25	68.1	68.8	63.4
30	63.7	64.2	60.9
35	59.3	59.6	58.3
40	54.9	55.0	55.8

organic matter digestibility for *Bos indicus* at the lower levels. At the higher levels of fibre content this difference tends to disappear.

Extensive interpretation of the difference observed in the present study is difficult. The coefficient of digestibility of a feedingstuff expresses a relation between the material under examination and the class of stock to which it was fed. Consequently, when comparisons of the digestibilities of different feedingstuffs are to be made, the same class of stock should be used throughout the study. Similarly, when digestive capacities of two different classes of stock are to be investigated the same feedingstuffs should be fed in both cases. If comparisons are not made in this manner but if, instead, different feedingstuffs are fed to different classes of stock then differences in digestibility coefficients can be interpreted as arising from differences between feedingstuffs, from differences in digestive capacity between the classes of stock, or from a combination of both. The results of French (1940), although somewhat limited in number and obtained in a comparison of Zebu with cross-bred animals, suggest that it might be profitable to devote attention to possible differences between the roughages of the two zones.

Summary

A statistical study was made of the influence of crude fibre on the digestibility of organic matter in roughage using American and Indian data.

The correlation between crude fibre and organic matter digestibility was highly significant and negative for both *Bos taurus* consuming temperate zone fodders and *Bos indicus* consuming tropical fodders. The association between crude fibre and organic matter digestibility was, however, less in the Indian data than the American.

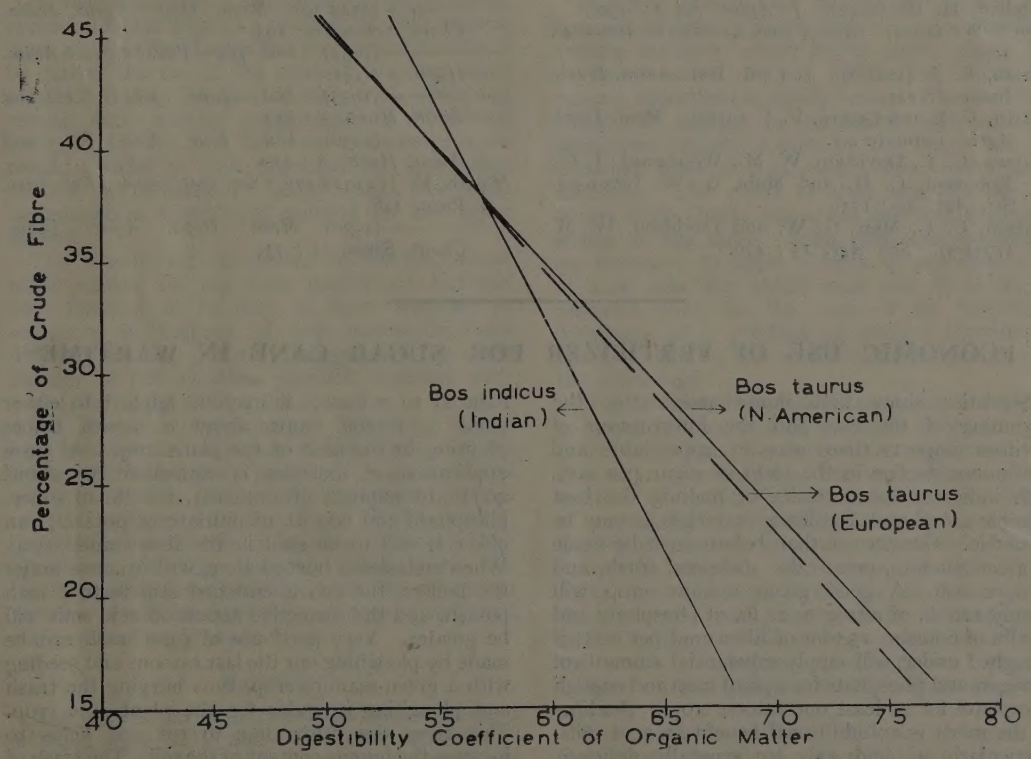

FIG. 3. The regression lines of digestibility coefficient of organic matter on crude fibre content for *Bos taurus* (European), *Bos taurus* (North American) and *Bos indicus* (Indian).

Each increase of one per cent. in crude fibre content depressed the digestibility of the organic matter by 0.9 per cent. in the American studies but only by 0.5 per cent. in the Indian studies.

Tropical roughage of low fibre content shewed lower digestibility coefficients when fed to Zebu stock than did temperate zone roughage fed to *Bos taurus* stock. Because of the lower regression of digestibility on crude fibre in tropical roughage fed to Zebu there was little difference in comparison of high fibre roughage.

Acknowledgment

The author is indebted to Mr. E. H. Achong for assistance in scrutinizing the literature and with the statistical calculations.

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ECONOMIC USE OF FERTILIZER FOR SUGAR CANE IN WARTIME

Statistics show that immediately after the beginning of the war and the interruption of fertilizer imports there was an appreciable and continuous decline in the yield of sugar per acre. This indicates the necessity of making the best possible use of such fertilizing materials as may be available. Greater use than before must be made of green manure, press cake, molasses, trash, and furnace ash. A good green manure crop will supply 120 lb. of nitrogen, 22 lb. of phosphate and 110 lb. of potash. 15 tons of filter mud per acre, if ploughed under, will supply substantial amounts of nitrogen and phosphate for a plant crop and enough phosphate for at least one ratoon crop; the lime in the muds is an additional benefit to acid soils, particularly as acid soils are generally deficient in phosphate. Molasses has proved particularly beneficial to soils deficient in phosphate. The customary use of 10 tons per acre may better be reduced to 5 tons; it may be applied to either plant or ratoon crops, about a month before planting in the case of the plant crop. A 5-ton application of molasses is equivalent to about 400 lb. of sulphate of ammonia, 100 lb. of superphosphate and 600 lb. of muriate of potash; an effect is still to be seen in the first ratoon crop. When molasses is burned along with bagasse under the boilers, the ash is enriched still further with potash, and the corrective action on acid soils will be greater. Very good use of cane trash can be made by ploughing out the last ratoons and seeding with a green-manure crop, thus burying the trash and ploughing it under for the plant-cane crop. This gives the trash time to rot and helps to increase the humus content of the soil. The trash of a 20-ton crop of millable cane will contribute about 52 lb. of nitrogen, 22 lb. of phosphate and 90 lb. of potash.—(*Soils and Fertilizers*, 8, 3, 179, 1945.)

FIELD TRIALS OF INSECTICIDES FOR THE CONTROL OF THE SUGAR-CANE FROGHOPPER

BY

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(*A paper read at the Third Conference of British West Indies Sugar Technologists, 1945, to appear in the Proceedings of the Conference and published here by permission of the British West Indies Sugar Association.*—Ed.)

THE year 1939 was the first of a series of four years during which the incidence of and damage caused by the sugar-cane froghopper were of exceptional severity. During those years the writer, with the close co-operation of Mr. H. E. Robinson, then Deputy Manager of Woodford Lodge Estate, conducted a number of field trials with pyrethrum as an insecticide for the control of this pest, as a result of which it was claimed that a practical method of control had been devised. Details of the methods employed and of the results obtained were communicated to those engaged in sugar production in Trinidad by a series of privately circulated reports and a general resumé was published in the Proceedings of the Agricultural Society of Trinidad and Tobago (*Proc. Agric. Soc. T'dad and Tobago*, **49**, Pt. 1, March, 1940, pp. 57-61).

In 1940 this method was employed as an estate operation rather than as a method of field experiment at Woodford Lodge and an attempt was made to extend the use of the method to other sugar estates. It may be said at once that, while the results were entirely satisfactory at Woodford Lodge, this was not the case elsewhere; as a result, dusting is still practised for froghopper control at Woodford Lodge but has been abandoned as a practical method on the other estates.

The reasons for the failure of the method on other estates are not fully understood but are now believed to be due, in large measure to variations in toxicity of the insecticide from different sources, probably exaggerated by unreliability of the war-time product, together with variations in the skill of the operators.

As, however, experience at Woodford Lodge had demonstrated that insecticidal control of the froghopper is definitely possible it was considered most desirable to continue the experimental work on this problem with the object of discovering, if possible, insecticides of greater efficiency than pyrethrum for this purpose. Such work has become particularly desirable with the advent of the new insecticides and the urgent post-war need for increased sugar production.

Materials

The insecticides employed in the trials conducted in 1945 were DDT and Sabadilla. Sabadilla is a new insecticide of vegetable origin developed by Dr. T. C. Allen of the University of Wisconsin and manufactured and marketed under licence from the patentees by two firms in the United States of America. I am indebted to Miss Jean M. Wilkowski, American Vice-Consul in Trinidad and formerly of the University of Wisconsin, for some information concerning this insecticide. Sabadilla is apparently a preparation from the seeds of *Schoenocaulon officinale* and related species of Liliaceous plants from Mexico and other Central and South American countries. Most of the present commercial supply appears to come from Venezuela. The toxic properties of the insecticide are due to the presence of the alkaloids veratrine and veratridine.

The nature of DDT and some of its more spectacular insecticidal properties are too well known to need description here.

Methods

In drift dusting for froghopper control the insecticidal dust is blown from a tractor-operated dusting machine, which moves slowly along the windward sides of the field. For successful dusting operations a steady breeze of low velocity (about 8 m.p.h.) is necessary and suitable conditions usually obtain in the sugar belt of Trinidad from 5 p.m. until some hours after midnight. The cloud of dust emitted by the blower drifts slowly across the field and gradually settles on the canes. Some skill and experience are necessary to apply a more or less even coat of dust over the entire area and it is highly probable that, in the case of an insecticide consisting of a mixture of several ingredients, the dust coat is not entirely homogeneous over the entire field.

It is obvious that laboratory tests of toxicity of insecticides are of little guidance in determining their suitability for large-scale application in this way. Furthermore, the very nature of the method of application precludes the possibility of employing statistical methods in evaluating the field results, since a randomised lay-out cannot be adopted. It is even impracticable to make use of a control plot for comparison with the treated area, since estate managements naturally do not wish to leave even a small area in which froghopper breeding can proceed unchecked, and possibly re-infect a large acreage of cane.

The methods which could be adopted to investigate the action of insecticides in the field were thus somewhat limited and, in order to overcome these difficulties as far as possible, the

following methods were adopted. Two adjacent beds were selected at random, running approximately in the direction of the prevailing wind across each field or part of a field which was to be investigated. The beds were divided by temporary marks into ten plots of equal size. A fixed number of cane shoots in each plot was then examined every day, a suitable number being between 30 and 40 shoots per plot and the number of adult froghoppers associated with each shoot was counted and recorded. In this way, variations in the froghopper populations, from day to day and also from place to place across the field, may be assessed with some accuracy. It is desirable that populations should be assessed in this way for about a week before any insecticidal treatment is applied, so that the population trend at the time of dusting can be determined. In most of the experiments discussed here, however, only a limited number of counts could be made before treatment owing to the urgent practical need to reduce the froghopper populations in the more heavily affected fields before serious injury occurred. Comparison of the populations before and after dusting affords a measure of the immediate apparent mortality and also indicates whether or not populations again rise to economically injurious levels.

All the insecticide mixtures were applied in the experiments at the rate of 20 pounds per acre.

Results

Experiments with DDT

Supplies of DDT were extremely limited during the year 1945 and the results of trials with this insecticide are not entirely conclusive, as the material available was inadequate for use in other than low concentration.

Figure 1 shows the curve of population of adult froghoppers across a field on successive days, both before (black lines) and after (coloured lines) treatment with DDT in 1 per cent. admixture with sulphur. The broken black line shows the populations about six hours before dusting and the continuous line the population twenty-four hours previously. Comparison of these two curves would seem to indicate that the population was falling naturally at the time of treatment but it is known that this was a temporary fluctuation and that the general trend of the population was a rising one at the time the dust was applied.

The mortality produced was much greater on the windward side of the field, nearer the dusting machine, than in the remoter half; indeed, populations continued to increase in the area represented by stations 8, 9 and 10. These facts indicate that DDT, even diluted to this extent, is capable of killing adult froghoppers provided that the application is sufficiently heavy, as in the windward half of the field, but that the toxic effect is otherwise unsatisfactory.

Essentially similar results were obtained with DDT in 2 per cent. admixture with sulphur, as shown in Figure 2 although a permanently depressant effect on the population is even more closely confined to the windward side of the field. More decisive and economically valuable results were obtained when DDT was used in 4 per cent. admixture, as shown in Figure 3. There was a significant diminution in the population fourteen hours after dusting and the population continued to decline progressively for a period of five days, although numerous adults were emerging daily and although the populations in neighbouring fields, which were not treated, continued to increase. After the expiry of six days after treatment the populations once more commenced to increase slightly, though not to such a degree as to cause economic injury. It may thus be stated that 4 per cent. DDT effected commercial control of the froghopper outbreak in this field.

In Figure 4 the mean population per stalk for the whole traverse is plotted against the date and affords a summary of the events following the application of DDT in each of these three cases.

Experiments with Sabadilla

While Sabadilla was used as the routine insecticide for froghopper control at Woodford Lodge during the wet season of 1945, opportunity for critical observations on the effect of this material occurred only in one field. The curves of populations across the field, both before and after dusting with Sabadilla, 30 per cent. in admixture with sulphur, are shown in Figure 5. It will be observed that there was a high mortality after fourteen hours and that the population remained more or less stationary at this low level. As in the cases already discussed, numerous adult froghoppers emerged after the dust was applied but populations never again attained a seriously economic level. In this case at least, Sabadilla gave results equal to those obtained by the use of 4 per cent. DDT and the fact that populations showed no significant rise is at least an indication that the insecticide exhibits some residual effect. Figure 6 is a summary of the changes in population on successive days both before and after dusting.

Experiments with mixtures of DDT and Sabadilla

In one heavily infested field an attempt was made to investigate the effect of dusting with a mixture of sulphur with 30 per cent. Sabadilla and 4 per cent. DDT. Results of this experiment were somewhat complicated by mechanical breakdown of the dusting machinery after the leeward half of the field had been dusted. Treatment was completed twenty-four hours later and the total application of twenty pounds of mixture per acre was thus applied in two instalments of ten pounds each. Figure 7 shows that an immediate mortality was produced in the remote half of the field and that a significant mortality occurred over the entire field when the second application of dust had been made. The mortality produced was in general satisfactory but at station 5 populations rose appreciably

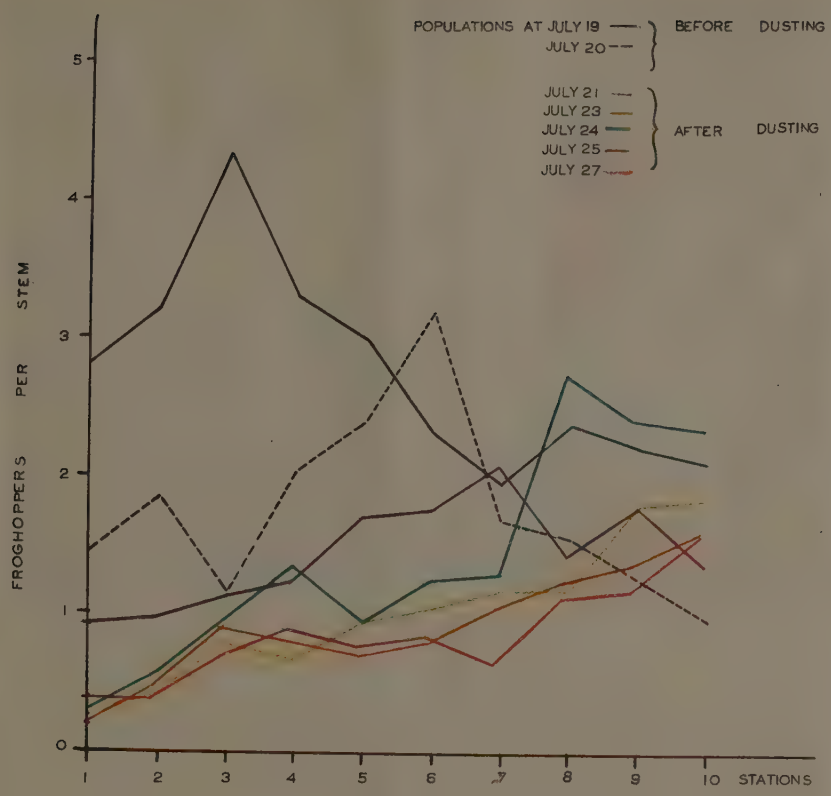
POPULATIONS AT JULY 19
JULY 20
BEFORE DUSTING
JULY 21
JULY 23
JULY 24
JULY 25
JULY 27
AFTER DUSTING
FROGHOPPERS PER STEM
0
1
2
3
4
5
1
2
3
4
5
6
7
8
9
10
STATIONS

Fig. 1

POPULATIONS AT JULY 20
BEFORE DUSTING
JULY 21
JULY 24
JULY 25
JULY 27
JULY 31
AFTER DUSTING
FROGHOPPERS PER STEM
0
1
2
3
1
2
3
4
5
6
7
8
9
10
STATIONS

Fig. 2

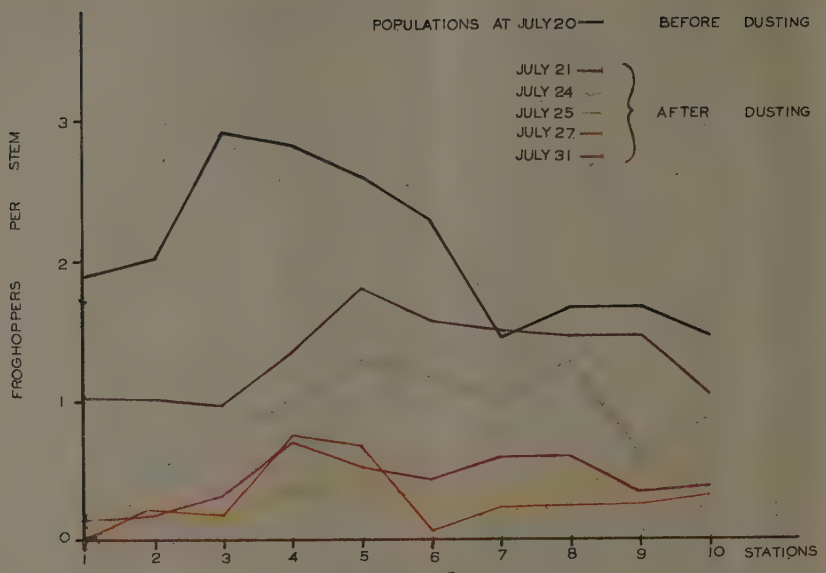
POPULATIONS AT JULY 20 — BEFORE DUSTING
JULY 21
JULY 24
JULY 25
JULY 27
JULY 31
AFTER DUSTING
FROGHOPPERS PER STEM
0
1
2
3
1
2
3
4
5
6
7
8
9
10
STATIONS

Fig. 3

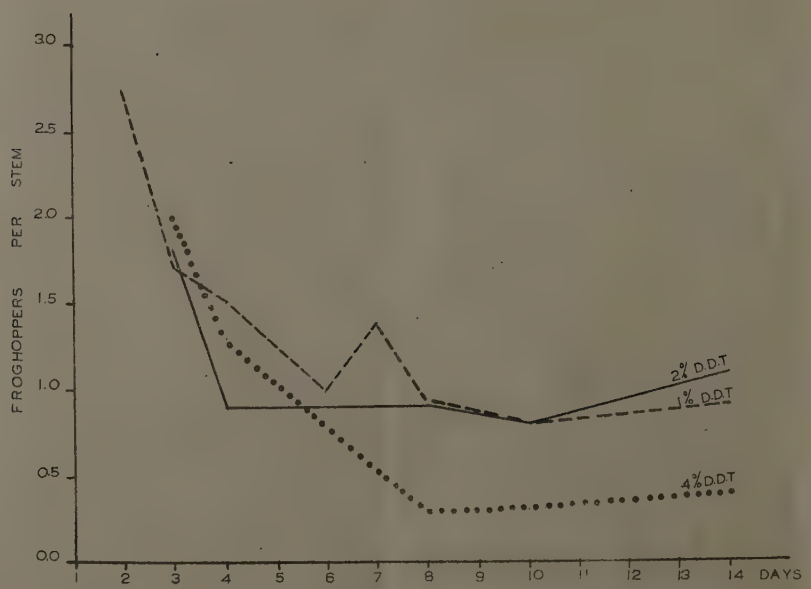
FROGHOPPERS PER STEM
0.0
0.5
1.0
1.5
2.0
2.5
3.0
2% D.D.T
1% D.D.T
4% D.D.T
1
2
3
4
5
6
7
8
9
10
11
12
13
14
DAYS

Fig. 4

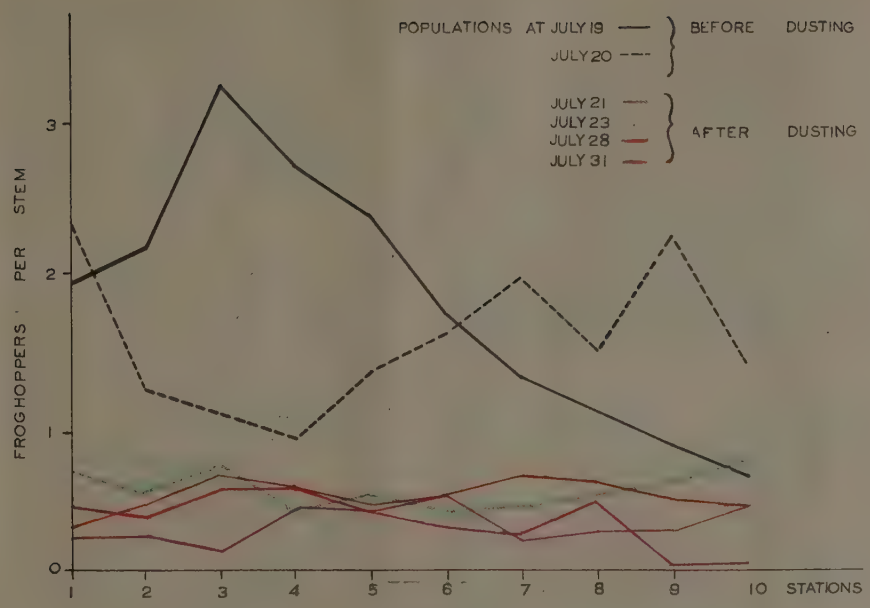
POPULATIONS AT JULY 19
JULY 20
BEFORE DUSTING
JULY 21
JULY 23
JULY 28
JULY 31
AFTER DUSTING
FROGHOPPERS PER STEM
0
1
2
3
1
2
3
4
5
6
7
8
9
10
STATIONS

Fig. 5

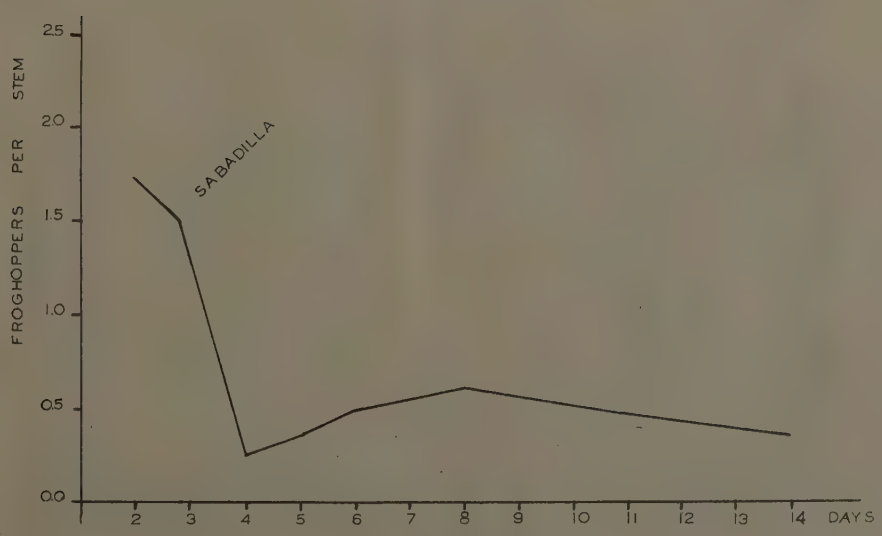
FROGHOPPERS PER STEM
0.0
0.5
1.0
1.5
2.0
2.5
SABADILLA
1
2
3
4
5
6
7
8
9
10
11
12
13
14
DAYS

Fig. 6

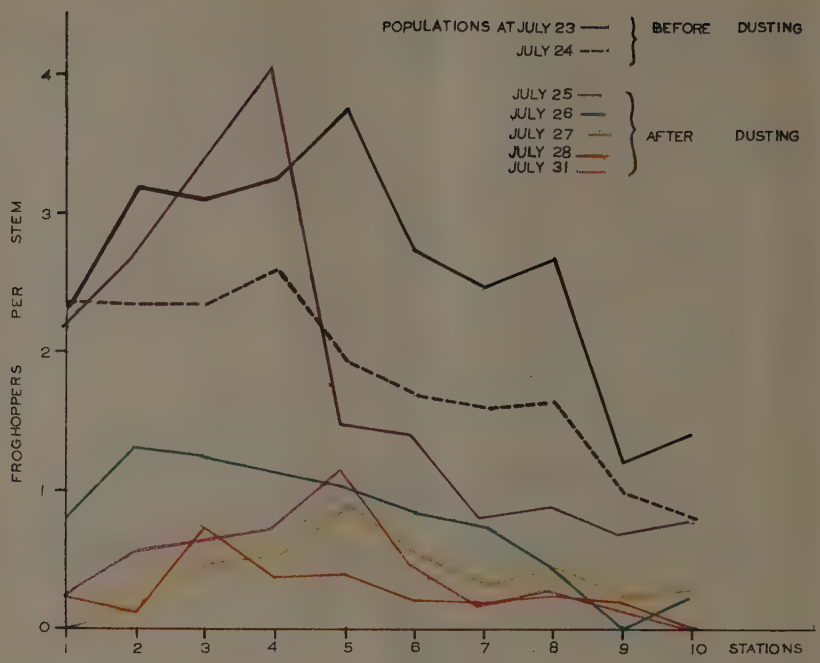
POPULATIONS AT JULY 23
JULY 24
BEFORE DUSTING
JULY 25
JULY 26
JULY 27
JULY 28
JULY 31
AFTER DUSTING
FROGHOPPERS PER STEM
0
1
2
3
4
1
2
3
4
5
6
7
8
9
10
STATIONS

Fig. 7

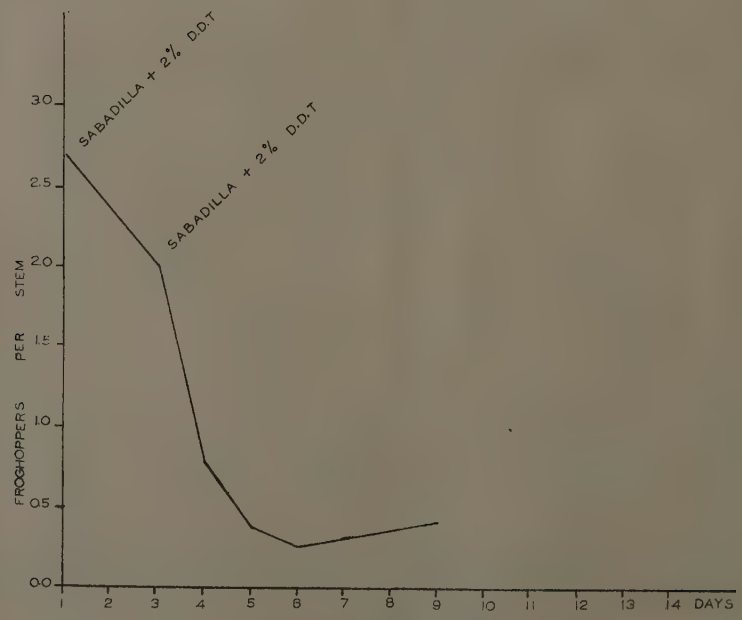
SABADILLA + 2% D.D.T
SABADILLA + 2% D.D.T
FROGHOPPERS PER STEM
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
DAYS

Fig. 8

seven days after dusting probably owing to a local variation in the quantity of dust actually deposited on the cane in this area. The mean populations for the entire traverse on successive days are shown in Figure 8.

It is a matter of regret that these studies could not be continued during the third brood outbreak, but lack of insecticidal material and the restricted nature of the outbreak rendered anything more than casual observations impossible.

Discussion

The experiments show that, in favourable circumstances, DDT in not less than 4 per cent. concentration, Sabadilla in 30 per cent. concentration and mixtures of the two insecticides are able to reduce froghopper populations of from 30 to 50 adults per stool to a level at which economic injury to sugar-cane does not take place. In the experiments detailed, adult populations were still increasing at the time the insecticides were applied, but not at a very rapid rate and it is probable that, in the case of a very severe outbreak, populations will again rise to economic levels after a single application of any of the insecticides if the populations are rising rapidly when dust is applied. The details of a scheme to control such an outbreak still require further study in order to determine whether it is better to administer up to three or four applications of insecticide during and after the period of most rapid emergence, or to delay until the peak of emergence is approached.

Examination of figures 4, 6 and 8 shows that, when DDT is used either alone or in admixture with Sabadilla, populations continue to decline for some days after the material is applied. When Sabadilla is used alone, however, the maximum effect is obtained on the day following dusting. This indicates, not only that DDT is a slow-acting insecticide but also probably that it has a marked residual effect and that it may be capable for some days, of killing insects which emerge after the dust is applied. Should this effect be still more marked when higher concentrations of DDT are employed, it is probable that DDT may be a most useful material for addition to insecticides used for froghopper control. The delayed lethal action of DDT may perhaps limit its employment without admixture with substances giving a quick "knock-down".

Conclusion

It is believed that DDT and Sabadilla show considerable promise as insecticides for froghopper control by the method of drift-dusting and the probable residual effect of DDT is likely to make it a most valuable ingredient of insecticidal mixtures for this purpose.

The shortage of pyrethrum and other contact insecticides of vegetable origin during the war years has given a great impetus to the production of synthetic insecticides and many other substances remain for trial, some of which may be superior to those discussed here.

Acknowledgments

The writer is indebted to Messrs. Woodford Lodge Estates, Ltd. for the full facilities afforded in carrying out these investigations. Especial thanks are due to Mr. W. E. Punch, in charge of pest control on Woodford Lodge Estates during the wet season of 1945, for his able assistance and co-operation.

ROOT FUNGI IN TROPICAL PLANTATIONS*

ROOT-INFECTING fungi are of great importance in the culture of tropical plantation crops. Unfortunately for the planter, tropical plantations are usually established on the site of cleared jungle, and the root-disease fungi transfer themselves from the roots of their jungle hosts to those of the young plantation crop. A plantation may stand for many years, and no break is afforded during which the soil is free of host plant roots, as it would be under a rotation of annual field crops. Great care has therefore to be taken to eliminate infected material from the soil when clearing a site for plantation cropping.

This procedure, if carried out conscientiously, formerly entailed much expensive digging for the extraction of plant roots. Recently, however, a most original method of root disease control has been evolved by R. P. N. Napper at the Rubber Research Institute in Malaya. By Napper's method, no digging of the jungle site, and only the essential minimum of clearing, is carried out before putting in the young rubber. Subsequently, at intervals of four to six months, the young trees are inspected by a pest gang of specially trained labourers for evidence of root infection. Such inspection involves a baring of the upper tap root and laterals of every young tree. When the mycelium of a root disease fungus is discovered, it is traced to its source—a buried, infected jungle root. The infected jungle root is extracted and destroyed, but the young rubber root is usually caught at a sufficiently early stage of infection for a very simple treatment to be effective. The mycelium of the root disease fungus, which is still at this stage epiphytic or superficial, is simply pulled off, and the surface of the root is rubbed with a 2 per cent. solution of copper sulphate. The success of the method depends upon the regularity of the inspections, so that potential root infections are discovered before the fungus mycelium has actually penetrated the inner tissues of the root. In this way, the young trees are themselves employed for the discovery of dangerous sources of root disease, and much expensive digging is thereby rendered unnecessary.

* Abstracted from an article by S. D. Garrett in *Endeavour*, **4**, 15, 1945.

SOIL FERTILITY OF SOME PEASANT LANDS IN TRINIDAD

Assessment by Chemical Analysis and Pot-tests

BY

F. HARDY* AND J. W. JORDAN†
(*Imperial College of Tropical Agriculture, Trinidad, B.W.I.*)

(I) Introduction

THIS account follows the same plan as previous articles that have appeared in this Journal describing laboratory and greenhouse tests applied to important agricultural soils and subsoils of the British West Indies.‡ These combined tests have demonstrated the widespread occurrence of marked *phosphate-deficiency* in the soils of this region, particularly soils that have deteriorated under agricultural usage. The particular soils that have so-far been examined are (*a*) black limestone soil from Antigua, (*b*) black marl soil and subsoil and (*c*) red ferruginous soil, the last two from South Trinidad, all three being well-known sugar-cane soils, and also (*d*) volcanic ash subsoils from St. Vincent, taken from cotton and arrowroot lands. Calcareous and ferruginous soils such as (*a*), (*b*) and (*c*) generally show marked discrepancy between the results of chemical tests (particularly the Truog test for available phosphate) and those of the Mitscherlich pot-test here applied; they may thus be regarded as "abnormal", since most other kinds of soil exhibit reasonable agreement.

Three other soils and their corresponding subsoils, occurring within peasants' holdings in North Trinidad, have recently been examined by chemical tests and pot-tests; the results obtained are presented below.

(II) Description of the soils

Location: The sites where representative soil samples were taken for examination were located in the western part of the Las Lomas District lying immediately to the east of Caroni Estate and to the south of the Caroni River (*see* the accompanying soil map). The area is traversed from west to east by the Caroni South Bank Road and by the Chin Chin Road, and from north to south by the Madras Settlement Road and the Las Lomas Roads, Nos. 1 and 2. The topography is undulating, becoming hilly towards the south-east, though flat over the river flood-plains. The greatest elevation is 200 feet (*see* the accompanying topographical map). The land is drained by several north-flowing tributaries of the Caroni River; the area forms a part of the Caroni Basin.

Soil-types: The three soil-types under investigation have provisionally been named by Dr. E. M. Chenery‖:—

(1) Sangre Grande Silty-Clay,
(2) Piarco Sand-on-Clay and Sandy-Clay,
(3) Arena Light Sand.

They will be described in turn.

(1) SANGRE GRANDE SILTY-CLAY

This is an alluvial soil widespread along the narrow valley flood-plains ("vegas") of the Northern Plain of Trinidad containing the Caroni and the Oropouche River systems flowing to the west and the east coasts respectively. It attains its widest expanse in the Sangre Grande area where the main tributaries of the Oropouche River form a broad alluvial flat that once was famous for high cacao production. Altogether, this soil covers about 50,000 acres of land of which some 27,000 acres are still under cacao, the rest being in second-growth bush ("lastro") or farmed by peasants. As a cacao soil, the Sangre Grande Silty-Clay is classed as sub-marginal and is ranked Grade III for productivity. The type sample was taken from a peasant's holding which had previously been growing cacao. Two composite samples were obtained within a half-acre block at depths 0-4 and 4-8 inches. The results of their laboratory examination by routine methods in vogue at the College are given in Table I.

Sangre Grande Silty-Clay is a very highly acid, ochre-yellow to fawn, uniform silty-clay, mottled orange on a grey ground below 6 to 12 inches depth. It shows partially-impeded drainage and is prone to waterlogging in the wet season. It thus exhibits some of the characteristics of a hydromorphic (swamp-land) soil. The contents of organic matter and nitrogen are variable in amount; the carbon-nitrogen ratio is usually low, indicating considerable loss of humic soil through surface erosion (wash). Available phosphate contents are generally low in amount and available potash medium-low. The sample examined is quite typical.

(2) PIARCO SAND-ON-CLAY AND SANDY-CLAY

This is a hydromorphic soil developed over quartzose and kaolinic detritus derived from the Northern Range metamorphic rocks. It was first described at the Piarco Savanna within the area now occupied by a large aerodrome. It occupies alluvial flats belonging to older river systems than those existing at the present day. The level topography and the abundance of clay in the subsoil partially impede the drainage. The natural vegetation is typically Marsh Grassland or Orchard Bush ("savanna"), though much of it is now "lastro". The soil is the least productive agriculturally of all the soils of Trinidad, though tonca bean and cashew nut thrive well on it.

The type sample was taken from Griffiths Settlement lying north of the Chin Chin Road. The area is partly in lastro and partly planted in

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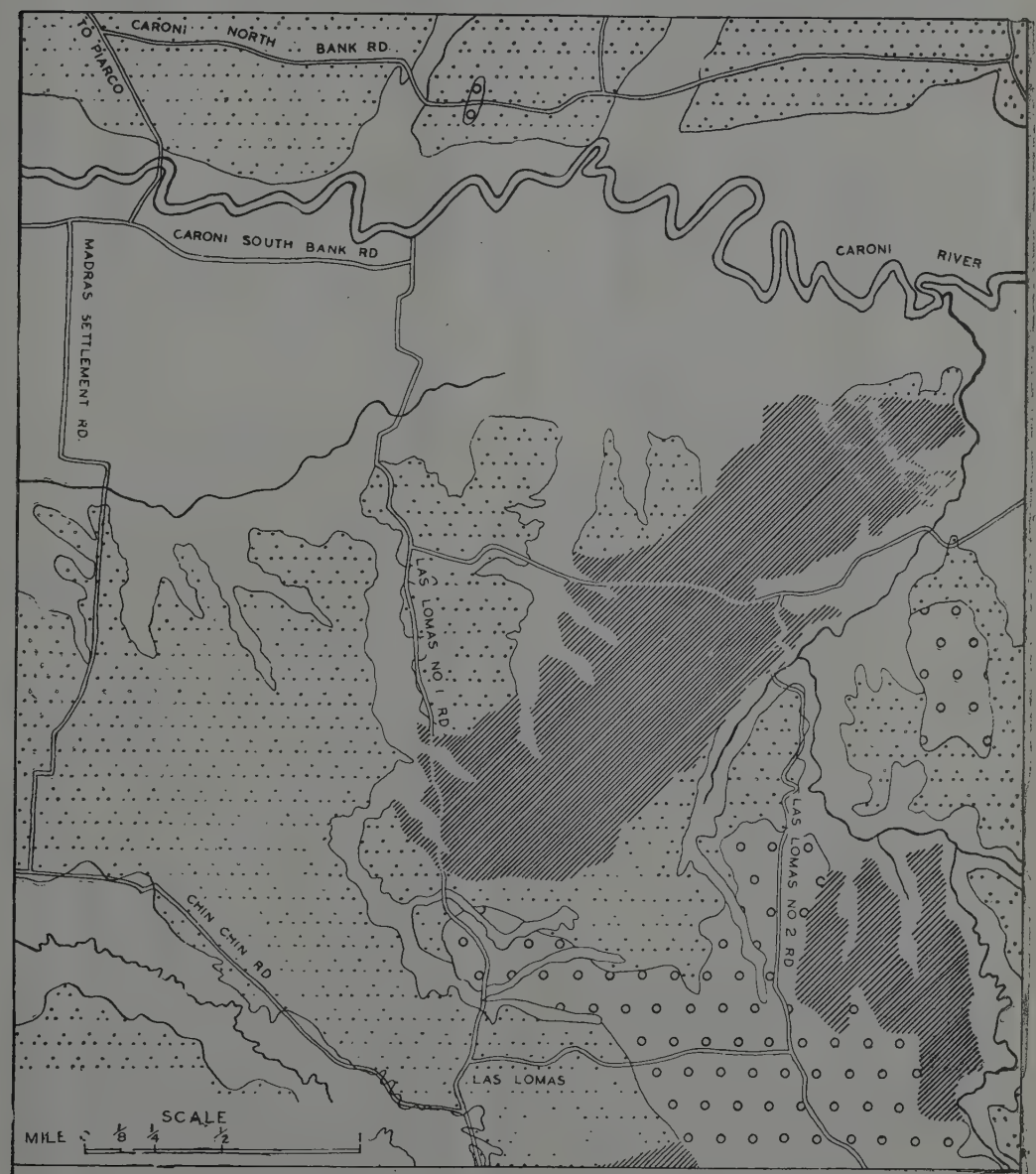
* Professor of Chemistry and Soil Science.

† Post-Graduate Student and Colonial Office Scholar, 1942-43.

‡ *Trop. Agriculture, Trin.*, **15**, 1938, pp.183-186; **18**, 1941, pp.214-221; *ibid*, pp.238-243; **21**, 1944, pp.30-39.

‖ A provisional classification of the soils of Trinidad, F. Hardy, *Trop. Agriculture, Trin*, **17**, 1940, pp.153-158.

SOIL MAP OF LAS LOMAS DISTRICT

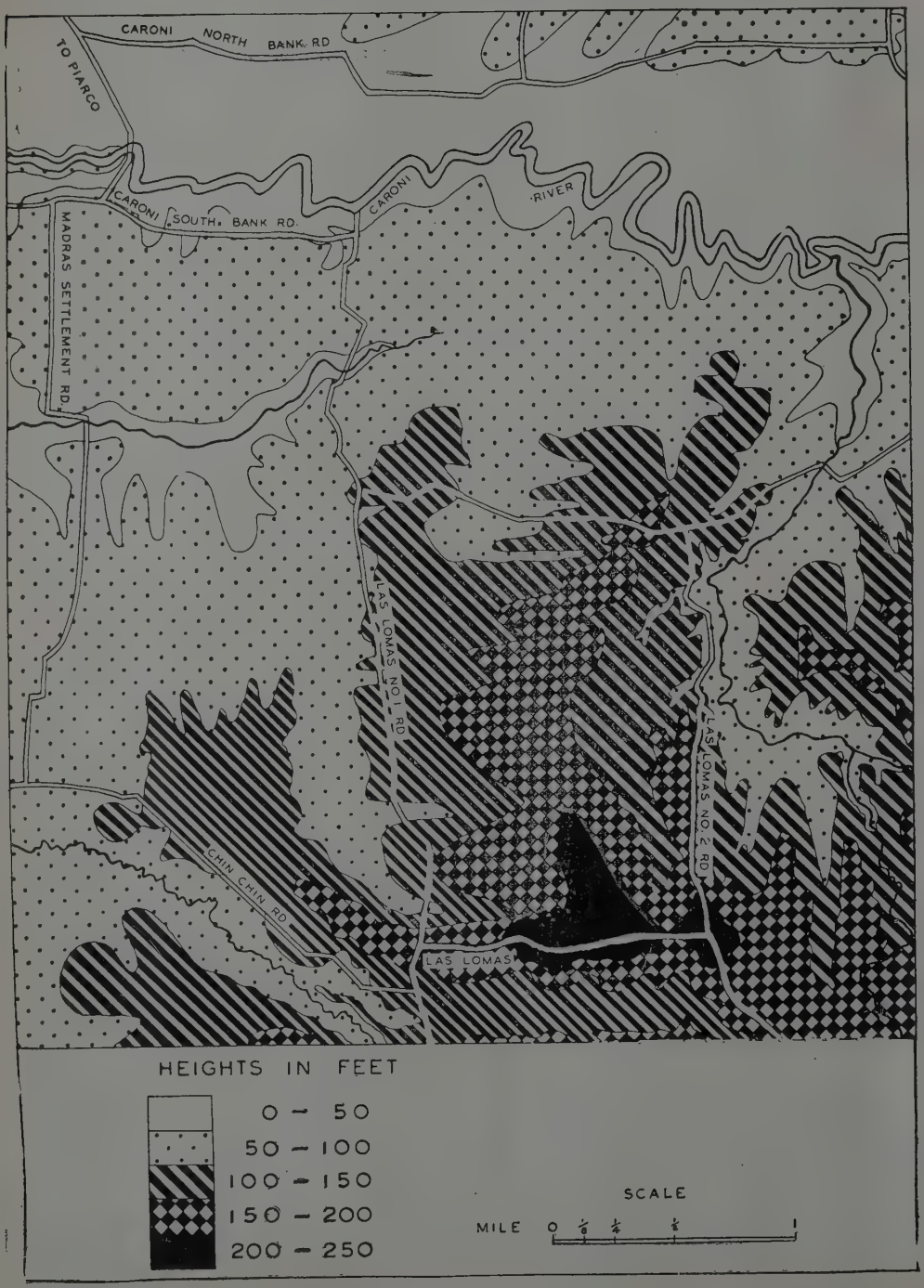


LEGEND

1. Sangre Grande Silty - Clay
2. Piarco Sand - on - Clay
3. Arena Sand
4. Talparo Clay

(After E.M. Chenery, 1942)

RELIEF MAP OF LAS LOMAS DISTRICT



peasants' food-crops. The sample was taken actually in lastro, under which the soil was "recovering" after two years cropping to ground provisions. As before, the depths of sampling were 0-4 and 4-8 inches. Laboratory data are given in Table I.

Piarco Sand-on-Clay and Sandy-Clay is a very highly acid, grey to grey-brown, loose, medium-grained sand of thickness up to 12 or 24 inches, merging below into pale-grey or yellow clayey-sand overlying parent material consisting of grey and white, yellow-stained clayey-sand changing to orange and crimson-mottled white kaolinic clay, occasionally containing quartz gravel, particularly at lower levels. The contents of organic matter and nitrogen are usually low, though uniform to considerable depth. Carbon-nitrogen ratio is high throughout. The contents of available phosphate and potash are low. The sample examined contained about 70 per cent. of coarse and fine sand. Its colour is grey, changing rapidly below through yellow to pale brick-red and becoming more and more clayey with depth.

(3) Arena Light Sand

This is a free-draining, loose, sandy, sedentary soil which is typically developed in the Arena Forest Reserve situated 6 miles to the east of the area in which the samples were taken. It occupies both hilly-land and flat plateaus comprising the dissected remnants of old river terraces. The natural vegetation is Evergreen Seasonal Forest (Crappo-Guatecare-Cocorite Association) which forms such remnants of "high woods" as still occur in the Las Lomas District. The soil is not very fertile; it differs but little in agricultural productivity from Piarco Sand last described.

The type sample was taken from high ground near the junction of the Chin Chin Road with Las Lomas No. 2 Road (*see* maps). The land was under shifting cultivation and in lastro at the time of sampling. The depths of sampling were 0-3 and 3-6 inches. Laboratory data are given in Table I.

Arena Sand is a very highly acid, loose, sepia-brown coarse sand, humic to about 12 inches depth, overlying 30 or 40 feet of loose, yellow, sometimes orange or brick-red, coarse sand. There is a gravelly phase containing detrital quartz pebbles of varying size. The contents of organic matter and nitrogen and the carbon-nitrogen ratio are similar to those of Piarco Sand. Available phosphate and potash contents are both very low. The sample examined is fairly typical.

(III) Lime status

It has been mentioned above that each of the three soils examined is very highly acid (Table I); their reaction values lie around pH 4.6. Only the first (silty clay soil) would be expected to have a high lime requirement, however, for the uptake of lime by a soil is a function of its base exchange capacity which is low in sandy soils. Data revealing the lime status of the soils are presented in Table II.

Explanation: *Column* 1. "Saturation capacity" measures the amount of exchangeable calcium (expressed as percentage of calcium oxide) needed completely to satisfy the base adsorption property of the soil. It is about twice as high in the silty-clay soil as it is in the two sandy soils. *Column* 2. "Available lime" measures the amount of exchangeable calcium actually present. *Column* 3. The difference between the last two values measures the degree of lime deficiency, *i.e.* the amount of extra lime needed to saturate the soil in its present condition. *Column* 4 is the same calculated in tons of calcium carbonate per acre 6-inches of soil, taken as weighing 2 million pounds. *Column* 5 gives the amount of lime required to raise the reaction value to pH 7.3, *i.e.*: merely to change the reaction to alkalinity regardless of the degree of lime saturation achieved. The method used in the determination is a volumetric electrode method.

Table I

Laboratory soil data

Soil-type	Lr. dpth. ins.	Sand %	Reaction pH	Total org. matt. %	Total N %	C/N ratio.	Avail. P_2O_5* p.p.m.	Avail. K_2O† p.p.m.
(1) Sangre Grande Silty-Clay ...	4	12	4.6	4.2	.29	8.6	33	99
	8	15	4.5	2.2	.20	6.5	30	—
(2) Piarco Sand	4	69	4.7	2.7	.12	13.0	26	71
	8	71	4.6	1.7	.09	11.4	14	—
(3) Arena Sand	3	77	4.7	2.6	.12	13.0	26	43
	6	75	4.6	1.9	.08	13.2	13	—

* Truog's method: Limit of adequacy; clays 55, sands 35 p.p.m.

† Exchangeable potash limit of adequacy; clays 200, sands 130 p.p.m.

NOTE: The laboratory data set out in Table I indicate that each of the samples is markedly deficient in available phosphate and available potash, especially the subsurface soils. The silty-clay soil (No. 1) is fairly well supplied with nitrogen but the two sandy soils contain only medium-low amounts.

Discussion: If it be desired to saturate each of the soils with lime, then about 8¾ tons per acre of ground limestone are needed theoretically for the first (silty-clay) soil, and about 4½ tons per acre for the other two (sandy)soils. As a result of numerous field experiments in Trinidad, half the saturation quantity has been found in practice to be more satisfactory than full lime requirement; this reduces the dressings to, say, 4½ and 2½ tons per acre.

If it be desired to make the soil alkaline only, then the dressings would be about 5½ and 2½ tons per acre respectively, which is approximately the half-saturation quantity. On the other hand, not all the ground limestone that can be purchased in bags is immediately reactive when applied to acid soil, for a part of it is relatively coarse-grained. To allow for this, the dosages should be increased by 50 per cent. It is therefore finally concluded that, in order to correct soil acidity in these three soils dressings of about 6 and 3 tons per acre of commercial ground limestone, such as can be purchased in Trinidad, should be sufficient for application to the silty-clay soil and to the two sandy soils respectively.

(IV) Results of the Mitscherlich pot-tests

Experimental procedure: This was the same as was used in previous cases already mentioned. For testing a single soil sample, twelve (12) standard Mitscherlich pots are employed, each treatment being run in triplicate. The treatments are :—

(i) *Minus* nitrogen; *i.e.*: phosphate and potash added (PK)

(ii) *Minus* potash; *i.e.*: nitrogen and phosphate added (NP)

(iii) *Minus* phosphate; *i.e.*: nitrogen and potash added (NK)

(iv) Complete nutrients; *i.e.*: nitrogen, phosphate and potash added (NPK)

The standard dosages of artificial manures added per pot are :—

(*a*) *Nitrogen*; 1.0 g.N. per pot, equivalent to 5.0 g. sulphate of ammonia

(*b*) *Phosphate*; 1.1 g. P_2O_5 per pot, equivalent to 6.4 g. superphosphate

(*c*) *Potash*; 1.5 g. K_2O per pot, equivalent to 3.0 g. sulphate of potash

NOTE: A dressing of 0.4 g. per Mitscherlich pot of any artificial manure is equivalent to about 1 cwt. per acre, so that these dosages represent dressings of 12½, 16 and 7½ cwt. per acre which may be regarded as sufficient to furnish a superabundance of the three essential nutrients.

In addition to artificial manures, supplied to correct nutrient deficiencies, the standard Mitscherlich treatment also includes 0.5 g. of sodium chloride and 0.5 g. of magnesium sulphate per pot, needed to made good possible deficiencies of sodium, magnesium and chloride. It also includes 1.5 g. of precipitated chalk (calcium carbonate) per pot. This amount of lime represents a dressing of only 4 cwt. per acre of chalk, equivalent to about 6 cwt. of commercial ground limestone, which is not at all adequate for correcting soil acidity in the majority of cases. The addition is intended merely to supply nutrient calcium in cases where there may be a lack of this element. For gauging the effect of lime in correcting a high degree of soil acidity, a special series of Mitscherlich pot-tests must be carried out in which the soil is adequately limed before the nutrients (artificial manures) are added to the different cultures.

Indicator plant: Numerous indicator plants have been tried in the past at the College* as substitutes for the standard oats used by Mitscherlich in Germany which will not grow

* *See* Investigations of the Mitscherlich method in Trinidad, B. de L. Inniss, *Trop. Agriculture, Trin.*, 1936, **13**, pp. 292-298.

Table II

Lime requirement laboratory data

Soil-type	Lr. dpth. ins.	1 Satn. capac.* % CaO	2 Avail. lime % CaO	3 Diff-erence % CaO	4 Lime req; ($CaCO_3$) Tons/ac. 6 ins.	5 Method of Hardy and Lewis Tons/ac. 6 ins.	6 Ratio (4)/(5)
(1) Sangre Grande Silty-Clay	4	0.66	0.11	0.55	8.8	5.2	1.7
	8	0.59	0.06	0.53	8.4	5.8	1.4
(2) Piarco Sand	4	0.29	0.02	0.27	4.4	2.5	1.8
	8	0.26	0.01	0.25	3.9	2.4	1.6
(3) Arena Sand	3	0.31	0.02	0.29	4.5	2.9	1.6
	6	0.26	0.01	0.25	4.0	2.6	1.5

* Method of Page and Williams.

satisfactorily in the tropics. The best so far discovered is Sudan Grass (*Andropogon sorghum*, var. *sudanense*) and this was used in the present investigation. Thirty-five (35) seeds were placed equidistant in each pot. The plants were watered twice daily in appropriate quantity. When flowering started, watering was stopped and the crop was allowed to dry out. It was then reaped and dried in an oven at 100°C. and weighed.

Yields: The mean weights of dry matter for corresponding triplicated cultures are recorded in Table III. No sand was mixed with the soil to dilute it. The cultures were placed in a greenhouse whose sides are made of netting to exclude birds and insects.

Conclusions: (1) The yield of the complete (NPK) nutrient culture is highest of all for the *Sangre Grande Silty-Clay*, doubtless because it tended least to dry out in the pots, the other soils being sandy and much less retentive of moisture. There was little difference in the yielding capacity of any of the subsurface soils when treated with full nutrient as compared with their corresponding surface soils.

(2) In each soil-type, the lowest yields were given by the "*lacking phosphate*" cultures (NK) for both surface and subsurface samples. The least yield of all was given by *Piarco Sand* which gave only 19 per cent. of the yield of the complete nutrient culture for the surface soil, and 26 per cent. for the subsurface soil, a mean of 23 per cent. By contrast, *Arena Sand* gave 39 per cent. and *Sangre Grande Silty-Clay* 65 per cent. These results fall into line with the values for available phosphate as determined by the chemical test, which were, 20, 20 and 32 p.p.m., showing that the silty-clay soil contained an intrinsically larger supply of available phosphate than the two sandy soils.

(3) The magnitudes of the yields of the *lacking nitrogen* cultures (PK) show that *Sangre Grande Silty-Clay*, both surface and subsurface samples, contains nearly sufficient nitrogen in available form to satisfy the needs of Sudan Grass, so that the yield of the PK culture was practically identical with that of the NPK culture. In other words, no benefit could be expected from manuring this soil with nitrogenous manures provided enough phosphate and potash is present.

On the other hand, the two sandy soils showed a great lack of assimilable nitrogen, since only 50 to 60 per cent. of the maximum (NPK) yield could be obtained in the absence of nitrogenous manure.

(4) The magnitudes of the yields of the *lacking potash* cultures (NP), which in each case lay around 60 to 70 per cent. of the maximum (NPK) yield, show that, while the soils are somewhat deficient in available potash (especially the sands), this nutrient is more abundant in them than available phosphate.

(V) Requirements of manures

Application of the Mitscherlich formulae: This enables one to assess the contents of available nutrients from the yield data for the indicator plant grown in the differently-treated cultures.

Table III

Mitscherlich pot-test data

(*Yields of Sudan Grass dry matter*)

Culture treatment	Surface soils		Subsurface soils	
	Mean yield (g)	Percentage of complete manure (%)	Mean yield (g)	Percentage of complete manure (%)
	(1) Sangre Grande Silty-Clay			
(i) PK	49.6	97	50.0	100
(ii) NP	34.9	68	36.1	72
(iii) NK	35.0	68	31.6	63
(iv) NPK	50.9	100	50.0	100
	(2) Piarco Sand			
(i) PK	21.5	55	19.4	49
(ii) NP	25.6	65	22.8	57
(iii) NK	7.5	19	10.2	26
(iv) NPK	39.2	100	39.6	100
	(3) Arena Sand			
(i) PK	27.2	61	20.5	61
(ii) NP	30.9	69	20.1	60
(iii) NK	16.6	37	13.6	41
(iv) NPK	44.7	100	33.3	100

The method of calculation need not be considered here as it has already been explained in a previous article.* The results of this calculation for the three soil-types are set out in Table IV. According to Mitscherlich, adequacy for soil nitrogen, phosphate and potash is represented by available nutrient contents equivalent to 4.80 cwt. ac. of nitrogen (N), 1.75 cwt. ac. of phosphate (P_2O_5) and 1.60 cwt. ac. of potash (K_2O). Hence in order to estimate manurial requirements, the contents of available nutrients, in cwt. ac., calculated from the yield data by means of the Mitscherlich formulae, are merely subtracted from these standard amounts. This has been done in Table IV.

Conclusions: (1) *Nitrogen requirement*: This is *nil* for the silty-clay but very high (14½ to 17 cwt. ac. of sulphate of ammonia) for the two sandy soils. Indeed the calculated requirement of sulphate of ammonia is about the same for these two soils as the theoretical maximum ammonia (15 cwt. ac. sulphate of ammonia=318 lb. ac. N) which any crop is supposed to be able to utilise, according to Mitscherlich's law.

(2) *Phosphate requirement*: This is high for all three soil-types (6.7 cwt. ac. superphosphate for the silty-clay, 9.6 and 8.6 cwt. ac. superphosphate respectively for the two sandy soils). These quantities are similar in magnitude to those previously obtained for other West Indies phosphate-deficient soils which ranged from 4 cwt. ac. of superphosphate for the South Trinidad black marl soil to 10 cwt. ac. for the ferruginous red soil and for the St. Vincent "terras" soil.

(3) *Potash requirement*: Reckoned on a weight basis in comparison with the other manures, the dosages of potash manure required (Table IV) would appear at first sight to be rather low for each of the three soil-types examined, namely, about 2½ cwt. ac. of sulphate of potash. Reckoned in terms of K_2O, however, the requirements are really quite high though not so high as for phosphate (P_2O_5), except in the case of the silty-clay soil.

By contrast, the potash requirements of the phosphate-deficient soils previously examined are relatively small, notably the South Trinidad black marl and red ferruginous soils which showed potash requirements of less than 1 cwt. per acre of sulphate of potash; these soils are derived from Miocene sediments which contain appreciable amounts of a potash-bearing clay mineral, possibly illite (hydrous mica).

Comparison with chemical data: For the purpose of comparing the results obtained for available nutrient contents of the three soil-types assessed by a growing plant in the Mitscherlich pot-test with those assessed by chemical extracting reagents, the values in Table IV have been recalculated as parts per million by applying appropriate conversion factors depending on the depths of soil sampling. In the case of nitrogen, however, accurate comparison is impossible because the chemical method measures total nitrogen whereas the Mitscherlich method determines the readily-available nitrogen. The comparisons are set out in Table V.

The data in Table V demonstrate (i) that about 5 per cent. of the total nitrogen in the sandy soils is available to the indicator plant; (ii) that the Truog extracting reagent (0.1 per cent. sulphuric acid) abstracts about twice as much phosphate as the indicator plant, and (iii) that only about one-sixth of the exchangeable potash is available to the indicator plant. Different results might have been obtained had indicator plants other than Sudan Grass been employed. Evidence has accumulated during our own experience that Sudan Grass is either not a "voracious potash feeder", or that its potash needs are small; hence its reliability for assessing the available potash status of a soil has been doubted. This behaviour might explain the fact that the content of available potash of a soil is apparently much smaller as assessed by the growth of Sudan grass than it is

* *See* Investigations of the Mitscherlich method in Trinidad. B. de L. Inniss, *Trop. Agriculture, Trin.*, 1936, **13**, pp. 292-298.

Table IV

Nutrient contents and manurial requirements calculated by Mitscherlich formulae

Soil-type	Lr. dpth. ins.	Nutrient contents			Manurial requirements					
		Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)	Artificial fertilizer equivalents S/A.	Super.	S/Pot.
		(cwt. ac.)			(cwt. ac.)			(cwt. ac.)		
(1) Sangre Grande Silty-Clay ...	4	Ex.	0.65	0.39	Nil.	1.11	1.21	Nil.	6.5	2.4
	8	Ex.	0.58	0.48	Nil.	1.17	1.12	Nil.	6.9	2.2
(2) Piarco Sand	4	4.55	0.10	0.39	3.25	1.66	1.21	16.3	9.8	2.4
	8	1.31	0.17	0.32	3.49	1.58	1.28	17.5	9.3	2.6
(3) Arena Sand	3	1.88	0.27	0.44	2.92	1.48	1.16	14.6	8.7	2.3
	6	1.92	0.30	0.34	2.88	1.45	1.26	14.4	8.5	2.5

according to the chemical test. Final opinion on the matter, however, cannot be offered until comparisons between the results of a large number of field experiments, Mitscherlich tests and chemical soil analyses have been made.

(VI) Requirement of lime

The laboratory data recorded in Table II and discussed in Section III above indicate that each of the three soil types possesses a relatively high theoretical lime requirement, namely; Sangre Grande Silty-Clay, 6 tons of commercial ground limestone per ac. 6 ins.; Piarco Sand and Arena Sand, 3 tons per ac. 6 ins. Unfortunately no special pot-tests were carried out with these soils to examine the effect on the yields of the indicator plant of combined dressings of artificial manures and lime proportionately applied according to their requirements.

A liming trial: A simple experiment was performed, however, with the two Sangre Grande Silty-Clay soil-samples to test the effect of lime on the response of Sudan grass to the full nutrient treatment (NPK). Four Mitscherlich pots were used for each soil sample. Two pots received the standard amounts of nitrogenous, phosphatic and potassic manures with no lime and two received similar manurial treatments with the addition of lime. The amount of lime added was equivalent to only 1½ tons per acre 6 ins., which is about one-quarter of the theoretical lime requirement for alkalinity, but it was very finely divided. The results obtained are given in Table VI.

Table V

Comparison of results of Mitscherlich pot-test and of chemical tests

(*Data for apparent available nutrient contents*)

Soil-type	Lr. dpth. ins.	(1) Mitscherlich test			(2) Chemical tests			Ratio: Chemical / Mitscherlich		
		Nitrogen (N)	Phosphate (P_2O_5) (p.p.m.)	Potash (K_2O) (p.p.m.)	Total nitrogen	Phosphate (P_2O_5) (p.p.m.)	Potash (K_2O) (p.p.m.)	Nitrogen	Phosphate	Potash
(1) Sangre Grande Silty-Clay ...	4	—	22	13	2860	33	99	—	1.5	7.6
	8	—	19	16	1960	30	—	—	1.6	—
(2) Piarco Sand	4	52	3	13	1220	26	71	23.6	(8.7)	5 5
	8	44	6	11	880	14	—	20.0	2.3	—
(3) Arena Sand	3	47	7	11	1160	26	43	24.7	3.7	3.9
	6	48	8	9	830	15	—	17.3	1.9	—
					Means		...	21.4	2.2	5.7

Table VI

Liming trial data

(*Sangre Grande Silty-Clay*)

	Culture	Treatment	Yield (Sudan Grass) (*g*)	Mean yield (*g*)	Increase due to liming (*g*)	Percentage increase
Surface soil (0-4 ins;) ...	1	NPK alone	33.1	34.3	13.9	40%
	2		35.4			
	3	NPK+ Lime	50.1	48.2		
	4		46.3			
Sub-surface soil (4-8 ins.) ...	5	NPK alone	Plants all died	0	—	—
	6					
	7	NPK+ Lime	47.2	49.0	—	—
	8		50.7			

Discussion: The results are disappointing in that the yields given by the full nutrient treatment in the absence of lime were not as great as those obtained in the first straight Mitscherlich test with this treatment. All the plants died in the sub-surface soil cultures and the yields for the surface soil averaged only 34.3 g. as against 50.9 g. in the original test (Table III). Nevertheless they show a 40 per cent. increase for liming, which at least may be taken to indicate that the soil would probably respond readily to liming in the field. It should be remembered that the standard Mitscherlich treatment involves a small dressing of lime (6 cwt. ac.) which doubtless plays its part in supplying nutrient calcium which may be the main need of the growing indicator plant and a serious deficiency in these (unlimed) soils. This small dressing was withheld from the full nutrient cultures in our experiment which may partly explain the relatively low yields obtained.

Modern views concerning the liming of soils no longer stress the need of a strictly neutral or alkaline reaction though they insist on a sufficiency of nutrient calcium as an essential factor in soil fertility. Alkaline reactions are nowadays regarded in many cases as indicative of definitely harmful conditions and highest yields are often obtained in the field on soils whose reaction values are well on the acid side of neutrality.

(VII) Peasant agriculture in the Las Lomas district

An economic survey of the area was carried out in 1943 by C. C. Parisinos.* The following notes are taken from his report:

Agricultural conditions: The land occupied by the Piarco Sand and the Arena Sand soil-types is barely cultivable; it is sometimes used for shifting cultivation, otherwise it is left in forest, or if cleared, converted into rough grazing. The sale of this land to peasants began about 1923. The land occupied by the Sangre Grande Silty-Clay soil-type, was formerly under cacao; it became derelict around 1940 and was rented to peasants for growing sugar-cane and rice. During the War, Government purchased 400 acres of this land and sub-let it to peasants for the production of food crops.

Cropping and manuring: During 1942-43, 47 per cent. of the total land area (600 ac.) controlled by peasants in the Las Lomas District was cultivated, 6 per cent. was devoted to grazing and 47 per cent. was in forest or lastro. Of the cultivated part, 29 per cent. was in sugar-cane, 10 per cent. in rice and 10 per cent in ground provisions. Most (81 per cent.) of the sugar-cane is grown on Sangre Grande Silty-Clay; only 8 per cent. is grown on the sands. Sugar-cane planted on recently-felled cacao land gives as many as 10 successive crops without replanting. On old "hard" land it gives only 2 or 3 ratoons. After many years of cropping on "hard" land, the canes may be dressed with pen manure and occasionally with artificials and lime. The factories to which peasants sell their cane used to supply them with sulphate of ammonia on credit and its use was steadily increasing until the War when it was no longer procurable.

Much of the pen manure that is made in the Las Lomas District is never used on the land but is destroyed or thrown away because of transportation difficulties, the peasants' holdings being generally situated some distance away from their houses and cattle sheds. Crop yields are poor. Sugar-cane in 1943 gave only 12½ tons per acre (plants and ratoons together); neighbouring estate sugar-cane gave 15 tons per acre.

Bush-fallowing: Most peasants consider that bush-fallowing is the best method of restoring soil fertility in the Las Lomas District. The crops are planted immediately after felling and burning and without tillage. The procedure is practicable, however, only where land is plentiful; it must be replaced by more permanent and intensive systems of agriculture as the pressure of the population on the land increases.

(VIII) Suggestions for soil improvement

Based on the results of chemical tests and pot-tests described in this article, the quantities of artificial manures and lime given in Table VII are recommended for ensuring high production in the three soil-types:—

Sandy soils: It is doubtful whether it would prove profitable to manure with artificials or to lime the two sandy soil-types, considering the large

* Unpublished dissertation presented in partial fulfilment of the requirements for Associateship, I.C.T.A., 1943. *See* condensed summary in *Trop. Agriculture, Trin.*, **21**; 1944; pp. 84-98.

Table VII

Recommended quantities of artificial manures and lime

Soil-type	Sulphate of ammonia (N)	Superphosphate (P) (cwt. per acre.)	Sulphate of potash (K)	Ground limestone (tons per acre)
(1) Sangre Grande Silty-Clay ...	up to 4	5 to 7	up to 2	2 to 6
(2) Piarco Sand	3 to 7	3 to 10	up to 2½	1 to 3
(3) Arena Sand	3 to 7	3 to 9	up to 2½	1 to 3

and costly dressings that are apparently required to bring them into high production. The soils are practically "sand cultures"; their physical properties are such that fractional manuring might have to be resorted to in order to obtain the best results because of losses brought about by heavy leaching under the prevailing high rainfall.

Silty-clay soil: In view of the great importance of the Sangre Grande Silty-Clay as a peasant-land soil, both now and increasingly in the future, it is recommended that its thorough investigation in the field be immediately undertaken. Because of its prominence as a farmers' sugar-cane soil in the Northern Plain area, neighbouring sugar-estate owners might agree to undertake the necessary large-scale manurial experiments and subsequently to supply on credit artificial manures of the kind and quantity found to be best. *First consideration should be given to the raising of the lime and the phosphate status.* For this purpose, relatively large dressings of lime and phosphatic manure will apparently be needed. Especially for phosphate, the application of dressings of the customary order of one, two or three hundred-weights per acre may entirely fail to produce a desirable condition in the soil and plant for the rapid assimilation of soil nitrogen. Furthermore, a lack of phosphate in the soil may prevent the proper utilisation of added artificial nitrogenous manures, for it is well known that phosphate and nitrogen are complementary in their action on plant-growth. Finally, in those areas of Sangre Grande Silty-Clay where soil nitrogen is deficient, the introduction of a system of leguminous cover-cropping on land that has been thoroughly limed and phosphated should lessen the requirement of artificial nitrogenous manure, or even preclude its employment entirely.

The prime need here is for properly-planned and carefully-executed field manurial experiments, based on the findings of the chemical tests and the pot-tests, on typical Sangre Grande Silty-Clay soil, both that which has recently been under cacao and that which has been growing crops for a number of years. It is fully realised that the true value of these tests, as applied in the simple manner described in this article, lies not in their reliability as precise methods for measuring nutrient contents, but rather in the indications they afford on which the rational planning of field manurial experiments may confidently be based. Too often the magnitudes of the dressings of manures used in field experiments are merely guessed in the absence of preliminary evidence which chemical tests and pot-tests may readily provide. In consequence, important interactions between soil, manure and plant may be missed, for it is primarily the soil that is manured, not the plant.

(VIII) Summary

1. This article describes chemical tests and Mitscherlich pot-tests applied to three more soil-types in continuation of similar tests previously applied to other West Indies soils, the results of which have already been published in this Journal.

2. The three additional soil-types are (1) Sangre Grande Silty-Clay; (2) Piarco Sand, and (3) Arena Sand, occurring in the Las Lomas District of North Trinidad. The first is a widespread river alluvial flat-land soil of considerable agricultural importance; the other two soils are almost uncultivated and of no agricultural value; they occupy hilly land mainly under forest lastro or shifting cultivation.

3. The tests show marked deficiency of available phosphate in all three soils, and of nitrogen and potash in the sandy soils. They also show high lime requirements, especially in the silty-clay soil. The unsatisfactory phosphate status is believed to have particular agricultural significance.

4. An account is given of the agricultural conditions and practices based on an economic survey of the area.

5. It is recommended that, in view of the growing importance of the Sangre Grande Silty-Clay as a peasants' land soil, field manurial and liming experiments, based on the findings of this investigation, be inaugurated, and that special attention be given therein to the particular rôle of phosphate and lime in improving the fertility of this soil-type.

6. The relative unimportance of the sandy soils renders costly field experiments unwarranted.

PHENOL AS A TERMITE REPELLENT

In tests in Puerto Rico on the protection of susceptible woods from attack by *Kalotermes* (*Cryptotermes*) *brevis*, Wlk. from which initial toxicity is of little importance as compared with permanence of repellency, samples submerged for ten minutes in solutions of 2, 5 and 10 per cent. phenol were attacked in 2, 3 and 4 days, respectively, whereas those treated with 2 per cent. fluorene, phenanthrene, fluoranthene and pyrene were protected for 73, 87, 360 and 195 days. Solutions of pentabromophenol, pentachlorphenol and hexachlorphenol were very effective protecting the wood throughout the tests at concentrations of 1, 2 and 1 per cent., respectively. Solutions containing 1 and 0.5 per cent. pentachlorphenol did so for 337 and 273 days, but the other compounds had no lasting effect at 0.5 per cent. Copper pentachlorphenate was much more repellent than the parent compound, 0.01 and 0.02 per cent. solutions protecting the wood for 27 and 42 days and a 0.05 per cent. solution throughout the period of observation. Other metals have shown a repellent effect and the possibility of obtaining even more effective repellents by combining metals with organic compounds is suggested.—(*The Review of Applied Entomology*, **33**, 8, pp. 233-264, 1945.)

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Occurrence of Auxins in Organic Manures

As part of an investigation to determine the rôle, if any, played by auxins or growth-substances in the soil, a number of the more common organic fertilisers or manures have been examined for their auxin or growth-substance content. The results obtained show that all the more common organic manures contain growth-substances, although in some the amount is very small. In some manures the auxin or growth-substance activity was found to be nearly entirely due to heteroauxin or B-indolylacetic acid, but contrary to an earlier prediction, this was found to be by no means the universal rule.—(*Jr. Soc. Chem. Ind.*, *64*, 5, 147.)

* * *

Extraction of Groundnut Proteins

DEFATTED groundnuts in the form of commercial oil cakes and solvent-extracted meal, have been extracted with dilute sodium hydroxide solution. The yield of protein falls with the severity of heating previous to extraction, especially above 100°. Solvent-extracted meal from nuts from many parts of the world gives protein of remarkably constant analysis. The oil content of groundnuts falls as distance of place of origin from equator increases, and at the same time, the nitrogen content rises. Upward to 90 per cent. of the nitrogen present is extractable from groundnuts by dilute alkali, but, of this, the precipitable protein varies between 55 per cent. and 85 per cent. Yield of protein by alkaline extraction bears no regular relationship to nitrogen content of whole nuts, but is roughly proportional to the nitrogen content of the oil-free meal.—(*Jr. Soc. Chem. Ind.*, *64*, 8, 221.)

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Bamboo for Controlling Soil Erosion

Many species of bamboo will serve in controlling erosion. Certain species are recommended because there is a marked difference in the industrial value of the various bamboos. Although the powder post beetle, *Dinoderus minutus*, is a serious pest of cut bamboo, the following commercial species have been found to be relatively resistant to this insect; *Bambusa textilis*, *B. tulda*, *B. longispiculata*, and *B. tuldoides*. These oriental species have a system of underground rhizomes which results in the development of confined clumps. On the continent there are temperate species which have a "running" habit of growth and consequently require some attention to prevent them from spreading and eventually becoming a menace. Bamboo grows best on rich, moist sandy-loam soil, although it can be established satisfactorily on submarginal land not particularly suitable for other crops. Tropical species require at least 50 to 70 inches of rainfall distributed throughout the year. These species will tolerate additional rainfall provided the planting is not located where water stands for prolonged periods. In areas definitely low in rainfall the species recommended above should be located on banks of streams or ponds. Bamboo is most successfully established when planted at the beginning of the rainy season though with an evenly-distributed annual rainfall, planting can be done at any time.—(*Journ. Amer. Soc. Agron.* 1945, 37, pp. 839-847.)

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Composting Practice on the Tongaat Sugar Estate

ON the Tongaat Sugar Estate, Natal, South Africa, which has 16,000 acres under cane and makes 70,000 tons of sugar annually, filter-cake (amounting to about 18,000 tons a year) is used in the following way: The trash on a field about to be ploughed out and fallowed is collected into heaps about 18 feet wide and of any desired length, using an ingenious machine known as a tumbler rake, drawn by two pairs of oxen. This rake collects the trash and dumps it where desired. The filter-cake is brought to the field from the factory by tram line, then by light mule-drawn wagons, and is placed on the heaps in layers a few inches thick, alternately with layers of trash. The heaps are built up about five feet in height and then left to mature. No water is added, the natural rainfall providing sufficient, nor is it necessary to ventilate the heaps, the material being sufficiently porous to admit the necessary air. Two turnings are usually required to bring the heaps to maturity. During this building-up process, which is done during the dry season immediately after the cane has been harvested, the oxen used for field operations are penned in successive portions of the field, more particularly those parts of the field that were observed to give the least cane. The oxen are fed on cane tops only and are rested for half the day, which results in their keeping in prime condition. When the pen is vacated, the trash is built into a heap, made into a compost, and applied to the weak areas.

When all the trash has been collected and stacked, the old stools of cane are ploughed out, using a tractor-drawn multi-furrow disc plow, or, in the lighter soils, a 3-ton Roman harrow. With the spring rains a crop of sunn hemp is sown and ploughed in some months later. Some sunn hemp is sown on the compost heaps also, and, when ready, is incorporated in the heap during the first turning. After the sunn hemp has been ploughed in, the field is ready for planting next spring, and when the field has been furrowed for planting, the compost is applied in the furrow and the cane planted on top of the compost. An application of at least 30 tons per acre is available, leaving further supplies for specially weak areas. This practice has proved remarkably beneficial to cane on light soils. The gain in cane yield on this estate in the last season was 45.88 tons, which was 60 per cent. above the South African average.—(*South African Sug. Journ.*, **28**, No. 9, p. 385.)